CRITICAL THINKING: PLUGGING (OR MOVING) A HOLE IN OUR SWISS CHEESE

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Forward

The purpose of this and previous papers is to 1) improve decision quality or avoid decision error consequences, 2) improve the judging of decision quality by those with outcome knowledge and 3) protect decision makers from inappropriate second-guessing by non-experts, in hindsight.

Abstract.

Relying largely on the military's design, testing and implementation, this paper proposes Critical Thinking (CT) training to augment current Recognition Primed Decisionmaking training (RPD). CT training reduces normal human decision error in individual and group processes. Individual CT can reduce or, in a specific case, close a hole in the Swiss Cheese model. In a group, CT can also move the hole out of alignment. Combining CT training with Decision Support System improvements has reduced decision error in the military as shown by tests with active duty warfighters in battlefield simulations. Wildland fire decision support systems need a critical look to make them cognitively friendly and supportive of CT. Human factors analysis should move forward from the current "reporting" phase which provides explanation, to pre-accident decision training in CT skills. "CT as Dialogue" can help implement fire Doctrine, including Leader's Intent, and improve Incident Command organizations as *communicating* entities. Situation awareness needs to include understanding the cognitive situation inside our heads as well as the exterior situation of the environment and of the people around us. CT can correct shortcomings of intuitive expertise in the "wicked" wildland fire environment. Practicing CT as Dialogue will improve the fire organization's position as a "High Reliability Organization (HRO)". The Army's current internet based CT training program is appropriate for wildland firefighters from squad bosses to incident commanders, and appears to be easily adaptable to wildland firefighting.

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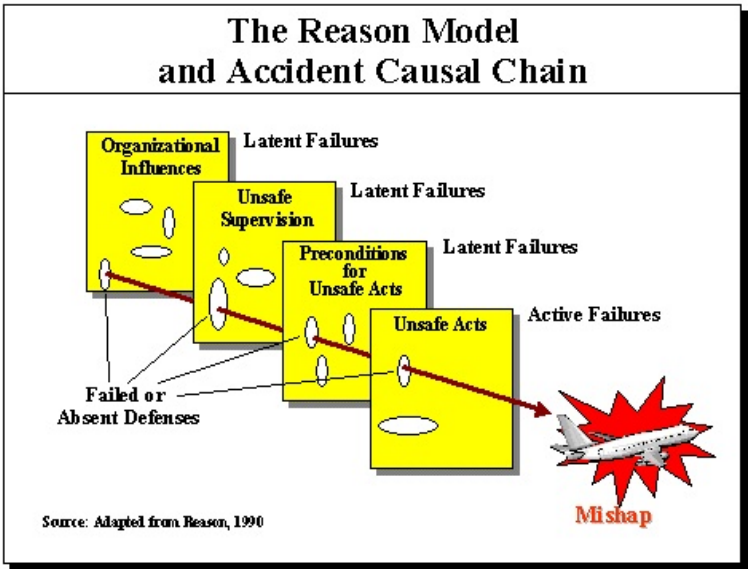
[1]The views herein are my own and not the position of the Department of Justice or the U.S. Attorney for the District of Arizona.

Introduction.

James Reason's widely known Swiss Cheese Model of system accidents is frequently employed to get at the "latent" systemic conditions which can align to allow normal human error to result in an accident. However, one of the holes of the Swiss Cheese Model is the "active failure" of normal human error, and Reason posits that the holes in the layers are themselves dynamic - moving, opening and closing. Human error: models and management, Reason, J., *BMJ*2000 ;320;768-770 doi:10.1136/bmj.320.7237.768 (2000).

CT as Dialogue also reduces the probability that a normal "active" human decision error will be allowed to align with other "latent" system weaknesses within an organization and lead to a mishap.



Reason posits that nearly all accidents involve a combination of both "latent conditions" and "active failures", so it follows that closing, reducing or moving out of alignment the hole represented by "active" normal human decision errors will reduce accidents. E.g., Use of Human Factors Analysis for Wildland Fire Accident Investigations, Ryerson, M. and Whitlock, C., In: Butler, B.W. and Alexander, M.E. Eds. *Eighth International Wildland Firefighter Safety Summit-Human Factors - 10 Years Later*; April 26-28, 2005 Missoula, MT., The International Association of Wildland Fire, Hot Springs, SD. On an individual basis, reducing decision errors reduces the hole and, in a given context, can close it. On a group basis (two or more people) the same can occur, or the decision error of one can be moved out of alignment by the other(s).

High Reliability Organizations employ CT skills as dialogue to prepare for and deal with the inevitable unexpected situations which can result in terrible outcomes for the organization and its members. HROs are *preoccupied with failure* rather than overconfidently complacent; they are

reluctant to simplify, instead, taking deliberate steps to obtain a more complete and nuanced picture of what they see in what is complex, unstable, unknowable and unpredictable; they are *sensitive to operations* at the tip of the spear, detecting and correcting weak signals; they maintain a *commitment to resilience* which avoids errors or perceives and corrects them early enough to avoid catastrophe; they employ *deference to expertise* down, up and around the organization to avoid typical harms caused by hierarchies. HROs build a *Just Culture* which encourages quick detection, reporting and correction of anomalies, deficiencies and errors before they lead to catastrophes. See Managing the Unexpected: Resilient Performance in an Age of Uncertainty, 2nd Ed., Weick, Karl E., Sutcliffe, Kathleen M., Wiley & Sons, Inc. (2007).

Wildland firefighting involves decisionmaking under stress and uncertainty in a dynamic environment. Most of the decisionmaking is done based on recognition of the situation and selecting an appropriate response from one's own experience dealing with similar situations. This Recognition Primed Decisionmaking (RPD) is the current training method used in wildland fire training courses. RPD is a process of Naturalistic Decision Making (NDM) which has some advantages over laborious analytical processes, including speed and agility on a military battlefield. E.g., The Recognition-Primed Decision Model, Bushey, D. Lt.Col. and Forsyth, M. Major (2006). On the other hand, Critical Thinking (CT) can be learned and practiced which reduces common decision errors made when only RPD is employed. The military has therefore combined both RPD training and CT training to take advantage of both. E.g., Meta-recognition in time stressed decision making: Recognizing, critiquing, and correcting, *Human Factors*, 38(2), 206-219, Cohen, M., Freeman, J.T., & Wolf, S. (1996).

Kahneman and Klein recently published a paper addressing intuitive expertise as a product of the type of environment in which the expertise develops. The sometimes "wicked" wildland fire environment provides irregular outcome cues, some valid, some not, which CT can moderate. The paper's abstract:

> This article reports on an effort to explore the differences between two approaches to intuition and expertise that are often viewed as conflicting: heuristics and biases (HB) and naturalistic decision making (NDM). Starting from the obvious fact that professional intuition is sometimes marvelous and sometimes flawed, the authors attempt to map the boundary conditions that separate true intuitive skill from overconfident and biased impressions. They conclude that evaluating the likely quality of an intuitive judgment requires an assessment of the predictability of the environment in which the judgment is made and of the individual's opportunity to learn the regularities of that environment. Subjective experience is not a reliable indicator of judgment accuracy.

Conditions for Intuitive Expertise, A Failure to Disagree, *September 2009, American Psychologist, Vol. 64, No. 6 515-526,* Daniel Kahneman and Gary Klein. Their paper notes that feedback from the environment can be misleading. Frequently suppressing fires without adverse incidents might be an example of misleading feedback. Citing Hogarth (Infra.) Kahneman and Klein explain that an

environment can be both "highly-valid" in that accurate cues and stable relationships exist, but also be "uncertain", citing poker and warfare as examples. I would view the wildland fire environment as only moderately valid (as when dealing with moderate or "routine" fire behavior) and as highly uncertain (such as extreme, plume dominated events). If this is correct, then the wildland fire task environment is a ". . .wicked environment[], in which wrong intuitions are likely to develop." Id. At 520. CT training and dialogue (System 2 thinking) can moderate intuitions which have been adversely affected by such an environment. Id. At 522.

Following a near miss or bad outcome, human decision error is typically found to be a causal factor. Human factors analysis helps us understand, after the fact, what contributed to the human decision errors. However, reading these reports does not constitute adequate training for firefighters to become critical thinkers. Lack of CT training perpetuates a hole in the Swiss Cheese Model which can be eliminated, reduced or taken out of alignment with other contextual factors present on the fire ground. In addition, improving decision support systems to employ and even to force critical thinking strategies and practices can further eliminate, reduce or realign this hole in the Swiss Cheese. The proof lies with other Federal agencies including the military, which is now fully engaged in critical thinking training coupled with improvement of decision support systems to be more cognitively compatible with normal human decision processes. This training appears to be easily modified to fit wildland firefighting.

Understanding Critical Thinking.

One working definition of Critical Thinking (CT):

> CT involves a deliberate, systematic awareness of the process and products of one's own thinking. The training program focuses on targeting common – and potentially serious – errors that people make when they fail to apply appropriate critical thinking skills. These errors include overlooking important details, misinterpreting information, and making incorrect assumptions – all of which can lead to poor decision-making. The training program highlights awareness of these errors and teaches specific techniques that can help people overcome them.

CRITICAL THINKING TRAINING FOR ARMY OFFICERS Vol. 1, Fischer, S.C., Spiker, V.A., (June 2004).

Another working definition:

> As a starting point, I will use Diane Halpern's broad definition of critical thinking as a foundation: "Critical thinking is the use of those cognitive skills or strategies that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned, and goal directed." In essence, critical thinking is about improving one's judgment. * * * critical thinking is the deliberate, conscious, and appropriate application of reflective skepticism. Some Army leaders refer to the

> "critical" in critical thinking as mere fault finding with either a conclusion or the process by which a conclusion was reached. Fault finding is not what critical thinking entails. The word "critical" really has to do with purposeful, reflective and careful evaluation of information as a way to improve one's judgment. (Footnote omitted)

THINKING CRITICALLY ABOUT CRITICAL THINKING: A FUNDAMENTAL GUIDE FOR STRATEGIC LEADERS, Gerras, S., Col., Ph.D. (2006).

Combining RPD and CT training.

Teaching and using **both** RPD and CT exploits the best of both RPD and CT. Id., Experts working with the military recognize the benefits of combining improved CT skills, a form of "meta-cognition", with good, experience-based RPD skills. They call this combination of RPD and CT "recognition/metacognition" (R/M). E.g., Meta-recognition in time stressed decision making: Recognizing, critiquing, and correcting, *Human Factors*, 38(2), 206-219, Cohen, M., Freeman, J.T., & Wolf, S. (1996):

> We describe a framework for decision making, called the Recognition/Metacognition (R/M) model, that explains how decision makers handle uncertainty and novelty while at the same time exploiting their experience in real-world domains. The model describes a set of critical thinking strategies that supplement recognitional processes by verifying their results and correcting problems. Structured situation models causally organize information about a situation and provide a basis for metarecognitional processes. Metarecognitional processes determine when it is worthwhile to think more about a problem; identify evidence-conclusion relationships within a situation model; critique situation models for incompleteness, conflict, and unreliability; and prompt collection or retrieval of new information and revision of assumptions. We illustrate the R/M framework in the context of naval tactical decision making.
> * * *
> In terms of training, the R/M model suggests that some crucial skills may not be as specialized as the task-specific structures emphasized in pattern-recognition, nor as general as the formal tools stressed in analytical models. In training based on these concepts, performance is improved by acquiring (a) effectively structured domain knowledge and (b) skills in questioning and revising that knowledge (Cohen, Freeman, Wolf, and Militello, 1995).
> * * *
> Proficient decision makers are recognitionally skilled: that is, they are able to recognize a large number of situations as familiar and to retrieve an appropriate response. Recent research in tactical decision making suggests that proficient decision makers are also metarecognitionally skilled. In novel situations where no familiar pattern fits, proficient decision makers supplement recognition with processes that verify its results and correct problems. The Recognition /

> Metacognition framework suggests a variety of metarecognitional skills that may develop with experience or serve as the objectives of training and as guidelines in the design of decision aids * * *.

Current wildland fire training consists almost solely of Recognition Primed Decisonmaking (RPD). RPD is, however, inadequate to sustain decision quality in some complex, dynamic, ambiguous, conflicting or poorly informed situations, which require CT to reduce decision errors. CT itself requires knowledge of how one's decisions are made, conscious effort to think critically of one's own emerging decision (or in analyzing someone else's orders), and the ability to systematically employ CT when faced with a complex and uncertain situation. CT requires knowledge, skill and ability to think about how one is thinking and to avoid ordinary pitfalls in human decision processes, including cognitive biases, heuristics (mental shortcuts) and unintended group decision influences. In Computerized Training in Critical Thinking (CT)²: A Skill Based Program for Army Personnel, ARI Contractor Report 2006-01, Fischer, S., Spiker, V.A., Harris, D., McPeters, E. (2006), Appendix A of that paper includes five pages of explanation concerning the relationship of CT and RPD and how training in both improves the quality of decisions. Here are a few excerpts (System 1 is similar to RPD and System 2 is similar to CT):

> . . . researchers have shown that expert performance in any field, which is commonly the gold standard, is often driven by intuition derived from extensive experience (e.g., Klein, 1999). That said, expert performance is not without fault, and studies have shown that even experts make errors in judgment when well-learned associations lead them astray. The associational processes used in System 1 [RPD] that make expert performance so quick and powerful are the same processes that are responsible for systematic errors that experts sometimes make. Additional weaknesses of System 1 [RPD] are that it depends on the quality and amount of experience an individual possesses, and it can't be used effectively in novel situations. System 2 [CT] reasoning also has its strengths and weaknesses. While it is highly useful in novel situations and problems, it is also slow and effortful. It usually cannot be utilized concurrently with other tasks and, like System 1[RPD], it can also produce wrong judgments.
> * * *
> Some models posit that System 1 [RPD] is the preferred system because it demands fewer resources and is less effortful to apply. Most recent theories, however, believe that Systems 1 [RPD] and 2 [CT] run in parallel and work together, capitalizing on each other's strengths and compensating for weaknesses. For example, many researchers believe that one function of the controlled deliberate process is to monitor the products of the automatic process. System 2 [CT] is thought to endorse, make adjustments to, correct, or block the judgment of System 1[RPD]. However, if no intuitive response is accessible, System 2 [CT] may be the primary processing system used to arrive at judgment. Sloman (2002) states that the systems work hand in hand as "two experts who are working cooperatively to compute sensible answers."

In that sense, the wildland firefighter who has been taught CT along with RPD and is practicing CT on the fire ground becomes two experts rolled into one firefighter - not just an experienced firefighter - or just an inexperienced firefighter - as the case may be.

Additional excerpt from Computerized Training in Critical Thinking (CT)²: A Skill Based Program for Army Personnel:

> CT skills can provide thorough examination of the problem at hand. While System 1 [RPD] typically derives only one solution (Klein, 1999), CT skills can provide multiple potential solutions. System 1 [RPD] works to narrow possible action paths, which is often highly effective when the task must be accomplished quickly and when the problem space is limited. However, when the problem space is novel or complex or when solutions must be innovative, CT skills are more powerful. CT skills have the meta-cognitive capability to monitor the progress of their own processing.

Finally, CT is an effortful skill which is not regularly practiced in the general population, so we cannot assume that firefighters can effectively use CT without training and practice on the fireground - last excerpt from Computerized Training in Critical Thinking (CT)²: A Skill Based Program for Army Personnel:

> There is a general consensus in the literature that individuals are reluctant to engage in CT. This is based on widespread observation of incoherent reasoning, nonsensical beliefs, lack of respect for evidence, poor CT test scores, and unsupported decision-making in various American populations. Indeed, much of the CT literature is devoted to a movement to increase the application of CT in various populations. One of the central topics has been the question of why the public seems disinclined to use CT.

Human Factors.

Accident reports typically identify poor decision quality (human error) as a causal factor. A recommendation from the fatal 30 Mile Fire, Management Evaluation Report (2001), page 12, is typical:

> Ensure that fire program managers, fire-line supervisors, and firefighters have situational awareness, assessment, and decision-making abilities necessary to successfully and safely transition command from initial attack to extended attack on incidents.

Current accident evaluation processes such as the Accident Prevention Analysis (APA), including the Indians Fire APA report (2008), help identify human factors and normal decision errors. The Indians Fire Human Factors analysis described 20 “Decision Factors” involved in the

incident. While it is beneficial for subject matter experts to identify decision making issues in post-accident reports, this kind of knowledge needs to be incorporated into training to improve decision quality **before** future incidents occur. Firefighters need to be provided with a sufficient working knowledge, skill, and ability to use CT skills in the field **before** an accident happens.

Forest Service Fire Doctrine includes imparting *Leader's Intent* through giving and receiving instructions. The Esperanza Fire Accident Report (2006) found that despite the high level of experience and training, *Leader's Intent* was not imparted:

> Finding 3.
> Engine 57 Captain was based in Idyllwild and had at least 16 years of working experience at the San Jacinto Ranger District.* * *
> Finding 4.
> Engine 57's Captain training history, including all position prerequisites including: L180 – Human Factors; L-280 – Followership to Leadership; L-380-Fireline Leadership; N9019 - ICT3 Simulation – Time Pressured Simulation Assessment; and S-215 – Fire Operations in the Wildland Urban Interface.* * *
> Contributing Factor 7.
> *Leader's intent* – Communications between Branch II and Engine 57 Captain at the Octagon House were not clear or understood.

CT training includes gaining a working knowledge of cognitive biases and heuristics (cognitive shortcuts). As explained in <u>THINKING CRITICALLY ABOUT CRITICAL THINKING: A FUNDAMENTAL GUIDE FOR STRATEGIC LEADERS</u>, Gerras, S. Col., Ph.D. (2006):

> Much research has been conducted on how people actually make decisions, especially under circumstances of high pressure, short timeframes, and with ambiguous, unpredictable information. Nobel laureate Herbert Simon proposed the term "bounded rationality" to describe the condition in which the limitations just noted cause decision makers to make seemingly irrational decisions (or at a minimum, sub-optimized decisions that simply have to do with negotiating constraints that restrict a fully rational framework (e.g., MDMP [formal Military Decision Making Process]). Such irrational decisions typically result from a reliance on intuitive biases that overlook the full range of possible consequences. Specifically, decision-makers rely on simplifying strategies, or "general rules of thumb" called heuristics, as a mechanism for coping with decision-making in the volatile, uncertain, complex, and ambiguous (VUCA) environment. Critical thinkers need to not only appreciate the framework for assessing their own thinking, but also need to appreciate the heuristics that most people rely upon when making decisions. The concept of heuristics relates strongly to the "automatic" mode of cognitive thought [RPD] described earlier. (Footnote omitted)
>
> Without much conscious awareness, people learn cognitive shortcuts, or heuristics, that work

well in most ordinary situations but are associated with systematic errors, or biases, under some conditions. Moderating these biases generally requires conscious deliberate effort, either to learn more effective cognitive strategies or to mitigate the shortcomings of the existing ones. Some examples of cognitive biases with self-evident implications for firefighters include:

Bias blind spot in which we tend not to recognize and compensate for our own cognitive biases.

The **planning fallacy** in which we tend to underestimate the time needed to complete a task (regardless of what task is tested).

The **confirmation bias** in which we tend to retrieve from memory information which confirms our working hypothesis while failing to retrieve, or ignoring, information which disconfirms it.

Sunk Cost fallacy in which we tend to continue doing that which we have already invested effort in, even if not objectively reasonable to do so.

Valence effect, wishful thinking, as opposed to evidence-based problem solving.

Outcome bias in which bad outcomes lead us to assume not only that the decision quality was bad, but so was the character of the decision-maker.

Belief perseverance in which we tend to use evidence to preserve our beliefs rather than to guide them.

Zero risk bias in which we prefer to reduce small risks to zero rather than address the larger risks.

Neglect of probability in which we tend to disregard probability when making decisions under uncertainty.

Framing in which we tend to solve a problem based on how it is initially framed, when better solutions could be obtained if the problem is re-framed.

Insufficient adjustment of anchors, estimating an unknown quantity by taking a known quantity as a starting point and overlooking or making insufficient adjustments for differences.

Base rate neglect, basing decisions on stereotypical similarity while ignoring the statistical frequency of an event.

Memory biases, the influence of salience or recency on recall and probability estimation

rather than actual frequencies of occurrence.

Self serving or egocentric biases which can influence decisions based too much on our personal motives, personal goals and protection of self interests.

Avoidance of **cognitive dissonance** in which our values change to conform to our behaviors.

CT does more than moderate normal biases and heuristics, but these examples suggest the obvious benefits of CT training to decision quality under stress and uncertainty. For an insightful example of how these biases and heuristics apply to the fireground from the perspective of a Hotshot, See A Human Factors Tool for Wildland Firefighters, Mayhew, B., (2005) In: Butler, B.W, and Alexander, M.E. Eds. 2005. *Eighth International Wildland Firefighter Safety Summit: Human Factors - 10 Years Later*; April 26-28 Missoula, MT. The International Association of Wildland Fire, Hot Springs, SD.

Good Situation Awareness supports good decisionmaking. However, we are operating largely without awareness of a very powerful part of the situation - the effectiveness of the largely unconscious cognitive processes that we are using to understand the exterior situation. CT training can give us a working knowledge of that part of the situation which we are currently overlooking. E.g., THE SITUATIONAL CHARACTER: A CRITICAL REALIST PERSPECTIVE ON THE HUMAN ANIMAL, 93 Geo.L.J. 1 (2004), Jon Hanson and David Yosifon:

> Our point in this discussion has been that there is more to the "situation" than what occurs outside of the human actor. Just as there is an unseen exterior situation that gives rise to the exterior fundamental attribution error [over-attribution of causation to personality or disposition while largely ignoring situational factors][2], there is an interior situation--undetected but incredibly powerful--that gives rise to the interior fundamental attribution error. Our experiences are wrapped in two layers of situational influences. To better understand what moves us requires understanding them both; and to better understand the power of either requires understanding its relationship with the other.
> * * *
> Situation, as we mean it, includes anything that influences our attitudes, memories, cognitions, emotions, behaviors, and the like in ways that we tend not fully to appreciate or control. The situation, then, is part of the human predicament: it is in and around us, it is influencing us, and it is doing so in ways that we do not appreciate, do not understand, do not have a place for in our theories, and do not individually or dispositionally control.
> * * *
> There is something familiar about the source of these well-documented heuristics. They are different ways of talking about the same basic phenomenon. They are all

[2]Bracketed text added for explanation.

> just manifestations in different contexts of what we have been describing throughout this Article and its companion: we see the vivid and we miss the pallid. Small pieces of the picture tend to dominate our assessment of the whole image. We readily see what is available, anchored, and presently normal, all according to how it had been framed, and we find it difficult to see much else. As Ziva Kunda puts it, these choice biases "may be viewed as a kind of mental contamination .... Even though we do not want our judgments to be contaminated in this manner, it is very difficult to eliminate the contamination."
> * * *
> That difficulty, we believe, is largely the consequence of our interior situations. We do not see these biases at work. We do not see, in other words, that we do not see. This inability to see our interior situation is the source of the interior fundamental attribution error. And our interior myopia helps give rise to the exterior fundamental attribution error.* * * We are dispositionists because of what comes to mind most easily--and, once in our minds, anchors our attributions. Interiorly and exteriorly, we humans miss the situational forest for the dispositional trees. (Footnotes omitted)
> * * *
> In short, this section has shown some of the ways in which, although it is true that we experience ourselves thinking, we do not think the way we think we think. There is more to the situation. And, as the next section illustrates, we have barely scratched the surface of our interior situations.
> * * *
> There is a tragic irony in our predicament. By blinding ourselves to the very forces that impinge upon our freedom, we are surrendering to them. To be serious about liberty requires that we not unwittingly turn over the situational strings to whoever has the means and ends to manipulate them. Indeed, our greatest dispositional act may be to acknowledge that we are situational characters and to choose to understand and gain some voice and control over the situation that largely controls us. In that very important sense, we do have a choice.

Additional reading for people interested in decision making and judging is this author's paper prepared for the Serious Accident Investigations course entitled "What was he thinking: Beyond bias to decision making and judging". A copy is posted on Wildlandfire.com in the archives section, documents worth reading:
http://www.wildlandfire.com/arc/arc.htm

Kahneman and Klein explain in Conditions for Intuitive Expertise, A Failure to Disagree, *September 2009, American Psychologist, Vol. 64, No. 6 515-526,* Daniel Kahneman and Gary Klein:

> . . . we do not believe that subjective confidence reliably indicates whether intuitive judgments or decisions are valid. When experts recognize anomalies, using judgments of typicality and familiarity, they are detecting violations of patterns in the *external* situation. In contrast, people do not have a strong ability to distinguish

> correct intuitions from faulty ones. People, even experts, do not appear to be skilled in detecting patterns in the *internal* situation in order to identify the basis for their judgments. Therefore, reliance on subjective confidence may contribute to overconfidence. Id. at 523.

and:

> An important characteristic of intuitive judgments, which they share with perceptual impressions, is that a single response initially comes to mind. Most of the time we have to trust this first impulse, and most of the time we are right or are able to make the necessary corrections if we turn out to be wrong, but high subjective confidence is not a good indication of validity (Einhorn & Hogarth, 1978). Checking one's intuition is an effortful operation of System 2, which people do not always perform—sometimes because it is difficult to do so and sometimes because they do not bother.
> * * *
> Subjective confidence is often determined by the internal consistency of the information on which a judgment is based, rather than by the quality of that information (Einhorn & Hogarth, 1978; Kahneman & Tversky, 1973). As a result, evidence that is both redundant and flimsy tends to produce judgments that are held with too much confidence. These judgments will be presented too assertively to others and are likely to be believed more than they deserve to be. The safe way to evaluate the probable accuracy of a judgment (our own or someone else's) is by considering the validity of the environment in which the judgment was made as well as the judge's history of learning the rules of that environment.

Id. At 522.

Intuitive responses by experts are *tacit* rather than *deliberate* and "are reached with little apparent effort and typically without conscious awareness. They involve little or no conscious deliberation." Educating Intuition, Robin M. Hogarth, University of Chicago Press (2001) at 14. But experts can also improve the quality of their intuitions (RPD) by managing their learning processes in the context of their specific domain, through exercises discussed elsewhere in this paper. Combining improved expert intuitive skills with CT's deliberative skills improves decision quality for both tacit and deliberative decisions. Mere exposure to the task environment is inadequate. One must manage the learning process in that environment to learn good intuitions and avoid bad ones. Id. Hogarth also explains that "[o]ur subconscious feelings may often prove wiser than our rational thoughts" and "in some cases our intuition may be more valid than analysis, that is, explicit attempts to reason. We know more than we are able to articulate" demonstrating the complexity of expert decision-making. Id. at 34 and 115. Psychologist Gerd Gigerenzer provides many interesting examples of intuition providing more valid decisions than explicit analysis in his book Gut feelings: the intelligence of the unconscious, Penguin Group, 2007. For many fascinating examples of intuition gone wrong, see the book SWAY THE IRRESISTIBLE PULL OF

IRRATIONAL BEHAVIOR, Ori Brafman and Rom Brafman.

Hogarth advocates treating emotion as data, and emotion can play a strong role in decision making under stress and uncertainty. E.g., Deep Survival: Who Lives, Who Dies, and Why, Laurence Gonzales. Hogarth also notes that intuition and deliberation are often interconnected. Id. at 14, so both must be educated, Id. at136. In sum, Hogarth states at page 14: "The major conclusion of this book is that intuition can be educated, and ways of doing so are, in fact, specified."

More recently, Daniel Kahneman explains decision quality issues involving Systems 1 and 2 in great detail. THINKING, FAST AND SLOW, Farrar, Straus and Giroux (2011). At page 417 Kahneman offers some conclusions:

> What can be done about biases? How can we improve judgments and decisions, both our own and those of the institutions that we serve and that serve us? The short answer is that little can be achieved without a considerable investment of effort. * * * The way to block errors that originate in System 1 is simple in principle: recognize the signs that you are in a cognitive minefield, slow down and ask for reinforcement from System 2. * * * Unfortunately this sensible procedure is least likely to be applied when it is needed most. We would all like to have a warning bell that rings loudly when we are about to make a serious error but no such bell is available, and cognitive illusions are generally more difficult to recognize than perceptual illusions. The voice of reason may be much fainter than the loud and clear voice of an erroneous intuition, and questioning your intuitions is unpleasant when you face the stress of a big decision. More doubt is the last thing you want when you are in trouble. The upshot is that it is much easier to identify a minefield when you see others wandering into it than when you are about to do so. * * * There is much to be done to improve decision making. One example out of many is the remarkable absence of systematic training for the essential skill of conducting efficient meetings. Ultimately, a richer language is essential to the skill of constructive criticism. * * * [Decision makers] will make better choices when they trust their critics to be sophisticated and fair, and when they expect their decision to be judged by how it was made, not only by how it turned out.

Situation awareness is thus more than fuels, topography and weather, but includes what is going on in our mind. As found in the fatal Esperanza Fire Accident Report:

> Causal Factor 1.
> There was a loss of situational awareness concerning the dangers associated with potential fire behavior and fire environment while in a complex wildland urban interface situation.* * *
> Causal Factor 2.
> The decision by command officers and engine supervisors to attempt structure protection at the head of a rapidly developing fire either underestimated, accepted,

and/or misjudged the risk to firefighter safety.

CT training can provide the knowledge and skills to more effectively deal with the total *external* and *interior* situations which profoundly affect the quality of our decisions.

Fire Doctrine's express commitment to decision quality.

Forest Service wildland fire Doctrine provides "[o]ur training will teach how to think, make good decisions, and act decisively, not what to think." FOUNDATIONAL DOCTRINE AND GUIDING PRINCIPLES for The Northern Region Fire, Aviation and Air Program, p. 11 (2006).

Similarly, the USDA/USDOI "2008 Direction to Leaders - Federal Fire and Aviation Programs" provides at page 3: "[e]very firefighter is responsible to be aware of the factors that affect their judgment and the decision-making process . . .".

Without CT training, which includes understanding cognitive biases, heuristics, group dynamics, and similar decision processes, firefighters cannot be expected to meet this expectation. Lack of CT training is a "latent condition" hole in the organizational slice of the Swiss Cheese Model. Lack of cognitively friendly Decision Support Systems, including quick check triggers, is another hole in the organizational slice.

Critical Thinking as Dialogue.

While CT is often seen as an individual skill, the Army has recognized its value in teamwork and superior-subordinate communications. E.g., Critical Thinking as Dialogue: A New Approach to Training Critical Thinking, ARI (Army Research Institute) Newsletter, V. 14, No. 1 (October 2004):

> Based on an analysis of current approaches to critical thinking and research in both cognition and communication, a new framework emerged that answers these challenges and is more likely to deliver the thinking skills required in real world contexts. The theory conceptualizes critical thinking as a dialogue. In general, a dialogue is any type of communicative exchange (verbal or non-verbal) between two or more people, such as a negotiation, deliberation, or expert interview, that has a characteristic structure of roles, constraints, and objectives. Critical thinking is a special type of dialogue whose purpose is to determine the acceptability of a belief or action, which proceeds by means of questions and answers about alternative possibilities, and which can be conducted both among different individuals and among different perspectives in a single person's head.
> * * *
> According to the dialogue approach, critical thinking is a process of asking and answering questions about alternative possibilities for situation understanding or action in order to achieve some objective.

* * *

A critical dialogue should improve the participants' understanding of the situation and plan, help them learn more about one another's beliefs, assumptions, and interests, and generate more successful decisions.

* * *

Based on these ideas, the training package, Critical Thinking Through Dialogue, was developed. Training takes trainees through four phases of a critical dialogue: (1) identifying a disagreement, (2) deciding how to resolve it, (3) challenging and defending positions, and (4) resolution.

* * *

Results showed that trained groups were more likely than untrained groups to recognize and set aside areas of agreement and to focus on areas of disagreement. They were also more likely to ask for and give reasons and less likely to prevent one another from expressing their views by interrupting. In addition to these process improvements, dialogue training led to an increase in new solutions that first emerged in the group discussion itself. These results suggest that dialogue training improves both the efficiency and effectiveness of group discussion. By focusing on disagreements, interrupting less, and asking and offering reasons more, trained participants overcame an experimentally confirmed tendency of groups to focus on information that all members already posses at the expense of valuable information they do not share. In addition, trained groups worked together to create genuinely novel solutions rather than simply choosing among the ones already championed by members of the group.

* * *

Dialogue theory studies reasoning and decision making as they actually occur in multi-person interactions rather than as a static set of logically related premises and conclusions. It seeks to identify the different types of argumentation that are observed in conversation and the kinds of errors to which they are subject. Dialogue blends descriptive and normative concerns. It is concerned with how effective a particular type of dialogue is for achieving the real-world goals of the participants in the current context and how effectively participants have conducted themselves so as to achieve the goals of that type of dialogue. Dialogue may be the way we both learn and apply critical thinking. For an individual, critical thinking is a mini-debate you carry on with yourself. In the military, however, decision making often takes place in a team context, offering an opportunity for true critical thinking dialogue. Dialogues are the interactions by which team members pool information and insights to solve problems, resolve competing goals, build up shared understanding of the situation and tasks, and construct relationships that improve team cohesiveness and trust. The fastest road to improved critical thinking in both an individual and a team may well be training for critical thinking dialogue.

For a scientific explanation of CT as Dialogue see Dialogue as Medium (and Message) for Training Critical Thinking, Cohen, M.S., Adelman, L., Bresnick, T., Marvin, F.F., Salas, E., Riedel,

S.L., (2006) In R. Hoffman (Ed.) *Expertise Out of Context*, Mahwah, N.J.: Erlbaum Associates.

Appropriate communication process is a critical component of successfully achieving and implementing Leader's Intent and Presence in the new Fire Doctrine. See Managing the Meaning of Leadership: Leadership as "Communicating Intent" in Wildland Firefighting, Ziegler, J., DeGrosky, M., *Leadership* 2008:4; 271 (2008). If Leader's Intent and Presence is indeed most effectively created throughout an organization as a mutual construct rather than the product of a mere conduit, then practicing CT as dialogue within that organization will clearly improve its ability to achieve the desired end state - in which everyone is thinking like the leader and carrying out the leader's intent. With everyone fully invested and thinking like the leader, a critically thinking organization would increase decision quality as instructions/intentions are discussed at the tactical level as the immediate situation continues to change.

It has also been demonstrated that within wildland fire organizations including the Incident Command System, treating *communication* failures as "latent conditions" of the organizational layer of Reason's Swiss Cheese Model, understates the "active failures" which organizations, as *communication* entities, can contribute to an accident. Fox, R. L., & Ziegler, J. A. Beyond Active Failures and Latent Conditions: Using Organizational Communication to Repair a Popular Accident Causation Model for Wildland Firefighting and other High Risk Industries. In *Extended Abstracts from the Human Dimensions of Wildland Fire Conference*, 10/23-25, 2007, Fort Collins, Colorado, S. McCaffrey, P. Woodward, M. Robinson, compilers. International Association of Wildland Fire, 135 pp. An organization in which "CT as Dialogue" is the communication **style** should reduce active communication errors such as vague or easily misinterpreted instructions which do not communicate intent, reluctance to ask questions, failure to challenge instructions based on changing situations or different information, etc.

Successful CT training.

The Army has recognized the benefits of CT training to enhance the overall ability to make good decisions under stress and uncertainty. RPD (recognition) is still recognized as important in familiar situations but CT (metacognition) serves as a check on RPD error and as a decision quality enhancer. E.g., Training metagognitive skills for situation asssessment, Freeman, J. T., & Cohen, M. S. (1994), In *Proceedings of the 1994 Symposium on Command and Control Research and Decision Aids*. Monterey, CA.

Coherence-shifting occurs in the face of conflicting and weak cues, in which we gain the confidence to make a decision and to act on it, by giving the weak cues more weight than is warranted in order to get to our (overconfident) decision. Learning to critically "consider the opposite" can reduce coherence-shifting by about half, thereby moderating overconfidence in an emerging decision which is based on ambiguous, conflicting, or weak evidence. A THIRD VIEW OF THE BLACK BOX: COGNITIVE COHERENCE IN LEGAL DECISION MAKING, 71 U.Chi.L.Rev. 511, 547 Dan Simon (2004). Similarly, the military's status-based trigger points and "quick check" de-biasing strategies increase decision quality in stress and uncertainty. E.g.,

Integrated critical thinking training and decision support for tactical anti-air warfare, Cohen,M, Freeman, J. & Thompson, B. In *Proceedings of The 3d International Command and Control Research and Technology Symposium*: CCRP; Decisionmaking in Complex Military Environments, Gary Klein (2002).

Statistical results of **improvements** in officer decision making from CT training include the following examples:

Reaction-initiative	53%
Mission purpose	23%
Pro-action plans	38%
Tactics	32%
Methods	34%
Options generated	40%
Issues considered	30%
ID of conflicting evidence	58%
No. of explanations	27%
No. of alternatives	41%
Accuracy of assessment	42%
Assessment agreement	41%
Assessment Confidence	20%
Contingency planning	217%

Statistics from: Cohen, M.S. & Adelman, L. (2002) Training critical thinking to enhance battlefield initiative. Proceedings of the Human Factors & Ergonomics Society, 46th Annual Meeting. Santa Monica, CA: Human Factors Society; Cohen, M.S., Freeman, J.T. and Thompson, B.B. (1998). Critical Thinking Skills in Tactical Decision Making: A Model and A Training Method. (Canon-Bowers, J. and E. Salas, eds.), Decision-Making Under Stress: Implications for Training & Simulation. Washington, DC: American Psychological Association Publications.

An excellent book with a chapter on specific practical exercises for improving intuitive decision-making skills in experts (RPD) is Educating Intuition, Robin M. Hogarth, University of Chicago Press (2001). His practical exercises are similar to the military version of CT training but sufficiently different to warrant reading this book and adopting the recommended practices. Some of these practices are listed at the end of this paper.

CT training model adaptable to wildland firefighting.

Over a period of nearly a decade the Army has developed, tested and deployed CT training in a format available on the internet to its battlefield personnel from squad leaders to generals. The training has proven effective in increasing decision quality in the face of uncertainty, and appears easily adaptable to wildland fire management. See Computerized Training in Critical Thinking (CT)^2: A Skill Based Program for Army Personnel, ARI Contractor Report 2006-01, Fischer, S.,

Spiker, V.A., Harris, D., McPeters, E. (2006). Comments describing this training made some years ago demonstrate clear parallels to the wildland fire setting:

> CTS [Critical Thinking Skills] are needed to adapt to a changing environment's complexity, uncertainty, ambiguity, and information overload. Army officers already have good sets of knowledge and skills, but providing explicit direction in how to think or reason can broaden and deepen those skills and have a multiplier effect on performance.
> * * *
> There are two aspects to CT: (1) the basic skills and abilities to think critically and (2) the disposition or willingness to use those abilities.* * *one may want to engage in critical thinking, but not have the required skills to do so.
> * * *
> Opportunities for CT arise when situational conditions make it desirable for a person to engage in CT. These conditions relate to the task or environment.
> * * *
> The Critical Thinking State shows three categories of skills and processes that are involved when an individual engages in CT. Meta-cognitive skills are those we use to monitor our own thinking. Meta-cognition is stepping back and observing ourselves -observing what we know and what we don't know, observing and judging the quality of our thinking, and making decisions about how to use our time and effort.
> ** *
> This training aims to improve the ability of Army tactical staff officers to quickly grasp the essential elements of a complex, uncertain, and dynamic situation, visualize those elements in terms of their units' goals, and take action in a timely and decisive manner. To accomplish these aims, four CTS were chosen for training. The first skill is keeping the goal of the mission upper most in mind and having it drive all aspects of planning. The second skill is time orientation -knowing when and how to be proactive, predictive, and reactive in planning and how to turn predictive courses of action into proactive courses of action, or reactive into predictive courses of action. The third skill is identifying problems in your mental model of the situation and then correcting them. Problems to look for include unreliable assumptions, missing information, and conflicts between information sources, tasks, or purposes. The fourth skill involves challenging your plan to see how and why it might fail even if you are certain it will succeed, and then changing the plan to deal with unaccounted for factors.

Training Critical Thinking Skills for Battle Command: How to Think, Not What to Think, ARI Newsletter, Spring 2001, Reidel, S., Leadership Development Research Unit, Army Research Institute (2001).

> The Army's CT training appears easily adaptable to wildland fire training.

Improved Decision Support Systems.

The military has also determined that decision quality under uncertainty can be enhanced by combining CT training with improved Decision Support Systems (DSS). CT and cognitive friendly DSSs compliment each other to improve decision quality and reduce decision errors. E.g., Integrated critical thinking training and decision support for tactical anti-air warfare, Cohen, M. Freeman, J. & Thompson, B. In *Proceedings of The 3d International Command and Control Research and Technology Symposium*: CCRP. The Wildland fire agencies would be well advised to take a critical look at their current DSSs for first line supervisors and higher decision makers. Is current briefing a critical thinking dialogue or just a conduit for orders which may not truly convey Leader's Intent and Presence? Are firefighters getting information they need in a cognitively friendly format, timely, and not mixed in with information they don't need. Is information relevant to changing situations adequately shared? Is the Incident Response Pocket Guide format cognitively friendly? Are there sufficient triggers and cognitive "quick checks" in place? For explanation see Principles for Intelligent Decision Aiding, Susan G. Hutchins (1996). Outside subject matter experts are available from the military's experience and should be consulted about current wildland fire decision support systems.

Conclusion.

Wildland fire agencies should design, implement and document Critical Thinking training (Red Carded), implement practices on the fireground which employ Critical Thinking as Dialogue, and re-design their Decision Support Systems to employ Critical Thinking strategies in cognitively friendly formats. Mishaps will be reduced. When mishaps occur, the professional firefighter will be in the best position to defend her decisions as a practicing subject matter expert in decision quality, against those who would second-guess her in hindsight, largely ignorant in decision theory.

Sample CT exercises.

(Adapted from the military STEP version and legal coherence theory):

1. "STEP" analysis:
   A. Build the **S**tory (mental model) past, present and future.
   B. **T**est the story against conflicting information, test assumptions, explain events' consistency with the story, revise the story.
   C. **E**valuate the story and assumptions-did you have to "stretch"? Missing information? Unreliable information or assumptions? If so, consider a new story.
   D. Formulate contingency **P**lans for the weakest assumptions in the story.
2. Part of this story appears to be wrong, explain why it could be wrong.
3. CT as dialogue - question, defend, explain, critique, revise the story.
4. Seriously consider the opposite (correcting for coherence shifts).

5. Act or think more?
    Costs of delay / Is there time?
    Are the stakes of an error high?
    Benefits of more investigation / thinking v. acting.

(Adapted from Training Intuition, Robin M. Hogarth, University of Chicago Press (2001):

1. Engineer your task environment to avoid misleading learning and promote valid learning.
2. Seek valid feedback.
3. Impose circuit breakers to interrupt tacit (as opposed to deliberate) decision processes - becoming more "mindful".
4. Acknowledge emotions as data.
5. Explore connections through imaginative narratives.
6. Accept conflict in choice-ask what are the trade offs.
7. Make scientific method intuitive-test the intuitive "first impression" as a matter of course.

Don't just look, learn to see- identify assumptions, what don't you see, what's missing, regularities and irregularities, similarities and dissimilarities.
Learn from what we see AND what we do not see.
Observe, Speculate, Test (seek to disconfirm, seek alternatives), Generalize to other knowledge/contexts.
What could change your mind?
Why do I think that?
How would I know if my idea is wrong?
Practice, practice, practice.